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Kosciusko County, Indiana

National Eutrophication Survey, Corvallis, Oreg

Prepared for

Corvallis Environmental Research Lab, Oreg

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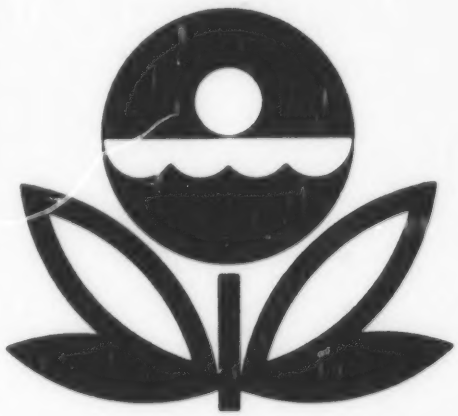
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES



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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT
ON
LAKE TIPPECANOE
KOSCIUSKO COUNTY
INDIANA
EPA REGION V
WORKING PAPER No. 342

WITH THE COOPERATION OF THE
INDIANA STATE BOARD OF HEALTH
AND THE
INDIANA NATIONAL GUARD
JULY, 1976

1a

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F O R E W O R D

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning {§303(e)}, water quality criteria/standards review {§303(c)}, clean lakes {§314(a,b)}, and water quality monitoring {§106 and §305(b)} activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Indiana State Board of Health for professional involvement, to the Indiana National Guard for conducting the tributary sampling phase of the Survey, and to those Indiana wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Division of Water Pollution Control, Indiana State Board of Health, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

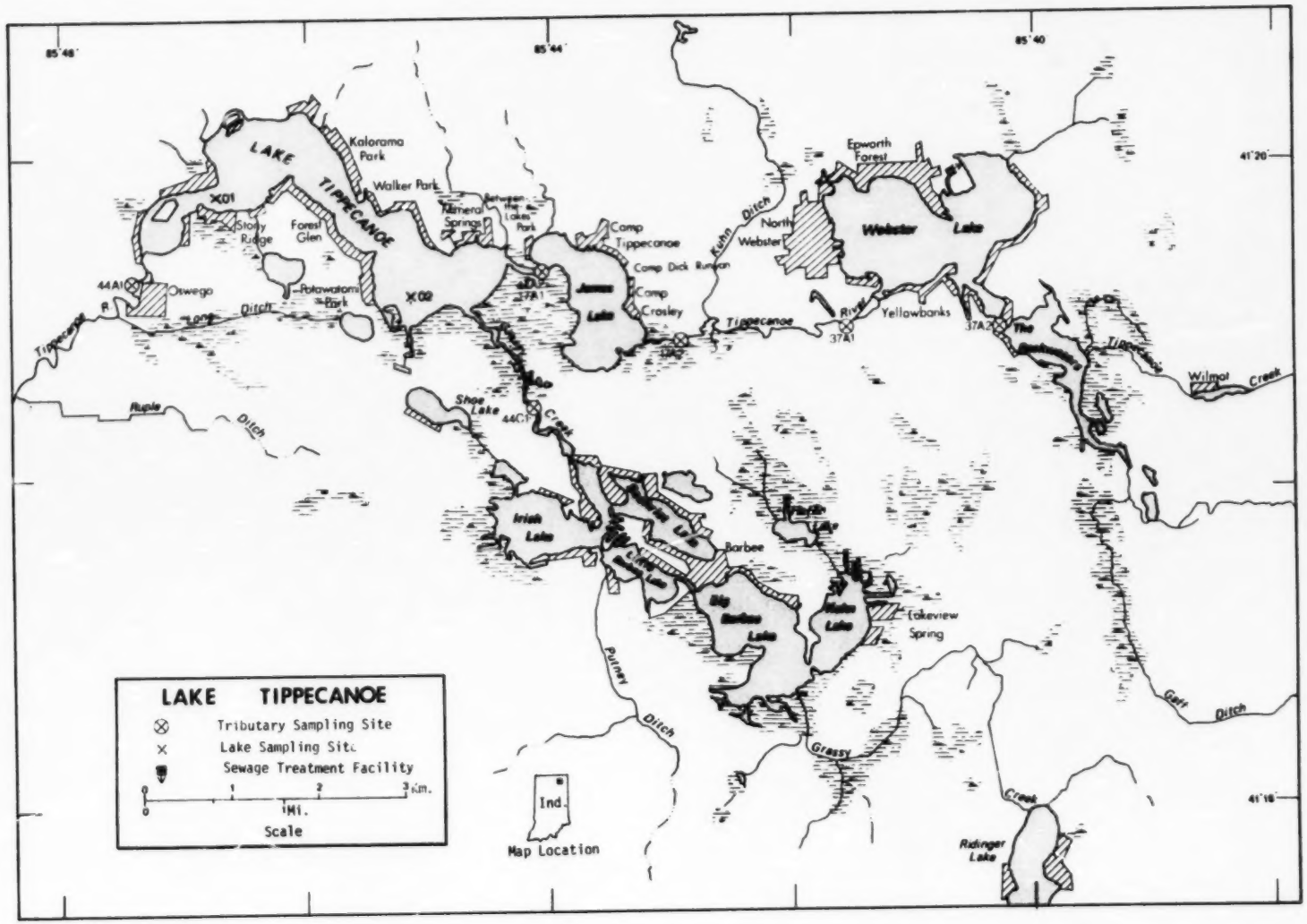
Major General Alfred F. Ahner, Adjutant General of Indiana, and Project Officers Lt. Colonel Charles B. Roberts (Retired) and Colonel Robert L. Sharp, who directed the volunteer efforts of the Indiana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF INDIANA

LAKE NAME	COUNTY
Bass	Starke
Cataract	Owen, Putnam
Crooked	Steuben
Dallas	LaGrange
Geist	Hamilton, Marion
Hamilton	Steuben
Hovey	Posey
James	Kosciusko
James	Steuben
Long	Steuben
Marsh	Steuben
Mississinewa	Grant, Miami, Wabash
Maxinkuckee	Marshall
Monroe	Brown, Monroe
Morse	Hamilton
Olin	LaGrange
Oliver	LaGrange
Pigeon	Steuben
Sylvan	Noble
Tippecanoe	Kosciusko
Versailles	Ripley
Wawassee	Kosciusko
Webster	Kosciusko
Westler	LaGrange
Whitewater	Union
Winona	Kosciusko
Witmer	LaGrange


85°48'
85°44'
85°40'
41°20'
41°16'
LAKE TIPPECANOE
Kalorama Park
Walker Park
Mineral Springs
Between the Lakes Park
Camp Tippecanoe
Camp Dick Rankin
Camp Crosley
Kuhn Ditch
North Webster
Webster Lake
Epworth Forest
Yellowbanks
Tippecanoe River
Wilmot Creek
Story Ridge
Forest Glen
Potawatomi Park
Oswego
Ditch
Ruple Ditch
Shoe Lake
Irish Lake
Barbee
Big Barbee Lake
Little Barbee Lake
Lakeview Spring
Pomeroy Ditch
Gatt Ditch
Grassy Creek
Ridinger Lake
X01
X02
44A1
37A1
37A2
LAKE TIPPECANOE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
0 1 2 3 Km.
0 1 Mi.
Scale
Ind.
Map Location

LAKE TIPPECANOE

STORET NO. 1844

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Lake Tippecanoe is mesotrophic. It ranked fourth in overall trophic quality when the 27 Indiana lakes sampled in 1973 were compared using a combination of six parameters*. Four of the lakes had less and one had the same median total dissolved phosphorus, four had less and three had the same median dissolved phosphorus, three had less median inorganic nitrogen, six had less mean chlorophyll a, and two had greater mean Secchi disc transparency. Hypolimnetic dissolved oxygen was depleted at station 2 in October.

Survey limnologists reported submerged macrophytes were common in the shallows near station 1 but were sparse near station 2.

B. Rate-Limiting Nutrient:

The algal assay results indicate the lake was phosphorus limited at the time the sample was taken (05/03/73). The lake data indicate phosphorus limitation at all sampling times.

C. Nutrient Controllability:

1. Point sources--No known municipal or industrial point sources directly impacted Lake Tippecanoe during the sampling year. However, municipal waste treatment facilities are planned

* See Appendix A.

for the Town of North Webster (BonHomme, 1976) with an effluent discharge to the Tippecanoe River upstream from James Lake* (see map, page v). The treatment plant will contribute some nutrients to Lake Tippecanoe via the river and the James Lake outlet, and it will be necessary to evaluate the possible significance of this new phosphorus source once the plant is put in operation.

The present phosphorus loading of 1.10 $g/m^2/yr$ is a little more than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 11). Apparently, much of the phosphorus input is utilized by macrophytes so that other symptoms of eutrophy are minimal.

2. Non-point sources--Both the Tippecanoe River and Grassy Creek drain relatively large lakes which have well-developed shorelines. The percentages of total phosphorus contribution of the streams are similar (44.9% and 48.3%) as are the non-point phosphorus export rates (11 and 12 $kg/km^2/yr$; see page 10).

* Working Paper No. 330

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 3.11 kilometers^2.
2. Mean depth: 11.3 meters.
3. Maximum depth: 37.5 meters.
4. Volume: 35.143 x 10^6 m^3.
5. Mean hydraulic retention time: 148 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Tippecanoe River	144.8	1.37
Grassy Creek	134.2	1.27
Minor tributaries & immediate drainage -	10.6	0.10
Totals	289.6	2.74

2. Outlet -

Tippecanoe River	292.7**	2.74**

C. Precipitation***:

1. Year of sampling: 79.7 centimeters.
2. Mean annual: 88.5 centimeters.

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† Table of metric conversions--Appendix B.
†† Winters, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake; outflow adjusted to equal sum of inflows.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Lake Tippecanoe was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 9.8 meters at station 1 and 9.1 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR TIPPECANOE LAKE
STORET CODE 1844

	1ST SAMPLING (5/ 3/73) 2 SITES			2ND SAMPLING (8/ 4/73) 2 SITES			3RD SAMPLING (10/13/73) 2 SITES		
PARAMETER	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN
TEMP (C)	11.9 - 13.4	13.1	13.2	14.0 - 25.6	22.7	23.6	15.5 - 19.8	18.9	19.5
DISS OXY (MG/L)	9.1 - 9.7	9.3	9.3	7.0 - 9.8	7.9	7.7	0.0 - 8.0	5.3	6.0
CNDCTVY (MCROMO)	495. - 500.	499.	500.	383. - 426.	410.	412.	376. - 385.	380.	380.
PH (STAND UNITS)	8.2 - 8.3	8.2	8.2	7.4 - 8.5	8.2	8.3	7.6 - 8.3	8.1	8.2
TOT ALK (MG/L)	200. - 204.	202.	201.	166. - 198.	172.	168.	163. - 187.	170.	171.
TOT P (MG/L)	0.017 - 0.028	0.024	0.025	0.013 - 0.019	0.016	0.016	0.016 - 0.030	0.021	0.019
ORTHO P (MG/L)	0.002 - 0.006	0.003	0.002	0.002 - 0.009	0.004	0.003	0.009 - 0.022	0.012	0.011
NO2+NO3 (MG/L)	0.100 - 1.200	0.950	1.050	0.060 - 0.710	0.180	0.110	0.030 - 0.100	0.054	0.050
AMMONIA (MG/L)	0.050 - 0.070	0.057	0.060	0.060 - 0.130	0.080	0.070	0.060 - 0.420	0.134	0.100
KJEL N (MG/L)	0.600 - 0.800	0.700	0.700	0.700 - 1.000	0.857	0.900	0.800 - 1.300	0.967	0.900
INORG N (MG/L)	0.160 - 1.270	1.007	1.105	0.120 - 0.840	0.260	0.180	0.100 - 0.450	0.189	0.150
TOTAL N (MG/L)	0.800 - 2.000	1.650	1.750	0.820 - 1.610	1.037	0.990	0.840 - 1.330	1.021	0.960
CHLRPYL A (UG/L)	4.8 - 5.5	5.1	5.1	9.2 - 9.6	9.4	9.4	2.9 - 4.3	3.6	3.6
SECCHI (METERS)	2.4 - 3.0	2.7	2.7	****** -**********			2.7 - 2.8	2.8	2.8

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/03/73	1. Fragilaria sp.	627
	2. Asterionella sp.	292
	3. Melosira sp.	292
	4. Flagellates	292
	5. Cryptomonas sp.	204
	Other genera	656
	Total	2,363
08/04/73	1. Cyclotella sp.	1,339
	2. Lyngbya sp.	854
	3. Oscillatoria sp.	602
	4. Microcystis sp.	427
	5. Synedra sp.	311
	Other genera	1,261
	Total	4,794
10/13/73	1. Lyngbya sp.	682
	2. Aphanizomenon sp.	185
	3. Scenedesmus sp.	128
	4. Dinobryon sp.	85
	5. Achnanthes sp.	85
	Other genera	440
	Total	1,605

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
05/03/73	1	4.8
	2	5.5
08/04/73	1	9.2
	2	9.6
10/13/73	1	2.9
	2	4.3

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.005	1.000	1.0
0.050 P	0.055	1.000	22.1
0.050 P + 1.0 N	0.055	2.000	30.2
1.0 N	0.005	2.000	0.2

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Lake Tippecanoe was moderate at the time the assay sample was collected. The significant increase in yield when orthophosphorus was added and the lack of increase when nitrogen alone was added indicate phosphorus limitation.

The lake data also indicate phosphorus limitation; i.e., the mean inorganic nitrogen/orthophosphorus ratios were 16/1 or greater at all sampling times, and phosphorus limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Indiana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff month of March when two samples were collected. Sampling was begun in June, 1973, and was completed in May, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Indiana District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads at station C-1, in $kg/km^2/year$, and multiplying by the ZZ area in km^2.

Nutrient loads at station A-2 were based on the flow and nutrient concentrations at outlet station A-1 of James Lake** which is the same location as inlet station A-2 of Lake Tippecanoe.

Note that estimates of septic tank phosphorus loads were reduced by 50% to adjust for the Indiana ban on phosphate detergents instituted in January, 1972.

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* See Working Paper No. 175.
** Working Paper No. 330.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Tippecanoe River	1,535	44.9
Grassy Creek	1,650	48.3
b. Minor tributaries & immediate drainage (non-point load) -	125	3.7
c. Known municipal STP's - None	-	-
d. Septic tanks* -	50	1.5
e. Known industrial - None	-	-
f. Direct precipitation** -	55	1.6
Total	3,415	100.0

2. Outputs -

Lake outlet - Tippecanoe River 2,410

3. Net annual P accumulation - 1,005 kg.

* Estimate based on 357 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Tippecanoe River	97,490	45.9
Grassy Creek	99,780	47.0
b. Minor tributaries & immediate drainage (non-point load) -	7,885	3.7
c. Known municipal STP's - None	-	-
d. Septic tanks* -	3,805	1.8
e. Known industrial - None	-	-
f. Direct precipitation** -	3,360	1.6
Total	212,320	100.0

2. Outputs -

Lake outlet - Tippecanoe River 171,350

3. Net annual N accumulation - 40,970 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Tippecanoe River	11	673
Grassy Creek	12	744

* Estimate based on 357 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	1.10	0.32	68.3	13.2

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lake Tippecanoe:	
"Dangerous" (eutrophic loading)	1.00
"Permissible" (oligotrophic loading)	0.50

V. LITERATURE REVIEWED

BonHomme, Harold L., 1976. Personal communication (planned waste treatment facilities at North Webster). IN Div. of Water Poll. Contr., Indianapolis.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Winters, John, 1975. Personal communication (lake morphometry). IN Div. of Water Poll. Contr., Indianapolis.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500- MEAN SEC	MEAN CHLORA	1ST MIN OD	ME [illegible] DISS [illegible]
1805	CATARACT LAKE	0.055	1.660	466.667	19.744	15.000	0.013
1811	GEIST RESERVOIR	0.074	1.080	472.500	45.950	11.600	0.009
1817	JAMES LAKE	0.024	1.030	434.000	11.533	15.000	0.004
1827	MISSISSINEWA RESERVOIR	0.107	2.400	473.444	15.778	15.000	0.024
1828	MONROE RESERVOIR	0.025	0.325	438.823	6.947	15.000	0.007
1829	MORSE RESERVOIR	0.084	3.325	473.222	56.167	15.000	0.009
1836	WAWASEE LAKE	0.012	0.210	364.500	5.000	14.600	0.003
1837	WEBSTER LAKE	0.025	0.790	431.000	11.500	15.000	0.005
1839	WHITEWATER LAKE	0.084	1.620	470.167	33.083	15.000	0.012
1840	WINONA LAKE	0.035	1.250	444.667	11.211	15.000	0.011
1841	WESTLER LAKE	0.035	0.860	427.125	10.712	15.000	0.013
1842	WITMER LAKE	0.035	0.980	440.333	11.917	15.000	0.011
1843	LAKE MAXINKUCKEE	0.020	0.220	400.400	5.483	15.000	0.003
1844	TIPPECANOE LAKE	0.019	0.195	391.500	6.050	15.000	0.005
1845	DALLAS LAKE	0.029	0.830	413.333	10.067	15.000	0.014
1846	OLIN LAKE	0.012	1.460	403.333	4.867	14.900	0.003
1847	OLIVER LAKE	0.009	0.920	392.000	3.767	14.800	0.004
1848	SYLVAN LAKE	0.170	0.130	469.833	47.480	14.800	0.017
1849	HOVEY LAKE	0.062	1.050	489.333	64.267	7.600	0.024
1850	VERSAILLES LAKE	0.139	1.090	482.000	25.078	14.500	0.019
1851	BASS LAKE	0.040	0.250	471.375	29.367	7.000	0.012
1852	CROOKED LAKE	0.019	0.120	410.111	5.578	15.000	0.005
1853	LAKE JAMES	0.014	0.190	352.444	4.856	15.000	0.005
1854	LONG LAKE	0.204	1.920	442.667	16.100	15.000	0.130
1855	PIGEON LAKE	0.058	1.445	442.667	11.400	15.000	0.015
1856	MARSH LAKE	0.093	0.270	451.333	34.467	15.000	0.055
1857	HAMILTON LAKE	0.033	0.720	413.167	17.450	15.000	0.019

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
1805	CATARACT LAKE	37 (9)	15 (4)	31 (8)	62 (16)	35 (0)	37 (9)	217
1811	GEIST RESERVOIR	27 (7)	35 (9)	15 (4)	12 (3)	92 (24)	62 (16)	243
1817	JAMES LAKE	73 (19)	42 (11)	58 (15)	50 (13)	35 (0)	65 (17)	323
1827	MISSISSINEWA RESERVOIR	12 (3)	4 (1)	8 (2)	38 (10)	35 (0)	8 (2)	105
1828	MONROE RESERVOIR	67 (17)	69 (18)	54 (14)	73 (19)	35 (0)	69 (18)	367
1829	MORSE RESERVOIR	23 (6)	0 (0)	12 (3)	4 (1)	35 (0)	58 (15)	132
1836	WAWASEE LAKE	94 (24)	85 (22)	96 (25)	88 (23)	85 (22)	98 (25)	546
1837	WEBSTER LAKE	67 (17)	62 (16)	62 (16)	54 (14)	35 (0)	81 (21)	361
1839	WHITEWATER LAKE	19 (5)	19 (5)	23 (6)	19 (5)	35 (0)	42 (11)	157
1840	WINONA LAKE	50 (12)	27 (7)	38 (10)	58 (15)	35 (0)	52 (13)	260
1841	WESTLER LAKE	50 (12)	54 (14)	65 (17)	65 (17)	35 (0)	37 (9)	306
1842	WITMER LAKE	50 (12)	50 (13)	50 (13)	42 (11)	35 (0)	52 (13)	279
1843	LAKE MAXINKUCKEE	77 (20)	81 (21)	65 (22)	85 (22)	35 (0)	98 (25)	461
1844	TIPPECANOE LAKE	85 (22)	88 (23)	92 (24)	77 (20)	35 (0)	85 (22)	462
1845	DALLAS LAKE	62 (16)	58 (15)	69 (18)	69 (18)	35 (0)	31 (8)	324
1846	OLIN LAKE	94 (24)	23 (6)	81 (21)	92 (24)	73 (19)	92 (24)	455
1847	OLIVER LAKE	100 (26)	46 (12)	88 (23)	100 (26)	79 (20)	88 (23)	501
1848	SYLVAN LAKE	4 (1)	96 (25)	27 (7)	8 (2)	79 (20)	23 (6)	237
1849	HOVEY LAKE	31 (8)	38 (10)	0 (0)	0 (0)	96 (25)	12 (3)	177
1850	VERSAILLES LAKE	8 (2)	31 (8)	4 (1)	27 (7)	88 (23)	15 (4)	173
1851	BASS LAKE	42 (11)	77 (20)	19 (5)	23 (6)	100 (26)	46 (12)	307
1852	CROOKED LAKE	81 (21)	100 (26)	77 (20)	81 (21)	35 (0)	75 (19)	449
1853	LAKE JAMES	88 (23)	92 (24)	100 (26)	96 (25)	35 (0)	75 (19)	486
1854	LONG LAKE	0 (0)	12 (3)	44 (11)	35 (9)	35 (0)	0 (0)	126
1855	PIGEON LAKE	37 (9)	8 (2)	44 (11)	46 (12)	35 (0)	27 (7)	197
1856	MARSH LAKE	15 (4)	73 (19)	35 (9)	15 (4)	35 (0)	4 (1)	177
1857	HAMILTON LAKE	58 (15)	65 (17)	73 (19)	31 (8)	35 (0)	19 (5)	281

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1836	WAWASEE LAKE	546
2	1847	OLIVER LAKE	501
3	1853	LAKE JAMES	486
4	1844	TIPPECANOE LAKE	462
5	1843	LAKE MAXINKUCKEE	461
6	1846	OLIN LAKE	455
7	1852	CROOKED LAKE	449
8	1828	MONROE RESERVOIR	367
9	1837	WEBSTER LAKE	361
10	1845	DALLAS LAKE	324
11	1817	JAMES LAKE	323
12	1851	BASS LAKE	307
13	1841	WESTLER LAKE	306
14	1857	HAMILTON LAKE	291
15	1842	WITMER LAKE	275
16	1840	WINONA LAKE	260
17	1811	GEIST RESERVOIR	243
18	1848	SYLVAN LAKE	237
19	1805	CATARACT LAKE	217
20	1855	PIGEON LAKE	197
21	1856	MARSH LAKE	177
22	1849	HOVEY LAKE	177
23	1850	VERSAILLES LAKE	173
24	1839	WHITEWATER LAKE	157
25	1829	MORSE RESERVOIR	132
26	1854	LONG LAKE	126
27	1827	MISSISSINEWA RESERVOIR	105

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1844 LAKE TIPPECANOE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 292.7

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1844A1	292.7	3.77	4.25	5.86	5.55	3.65	2.72	1.68	0.71	0.62	0.69	1.44	2.55	2.78
1844A2	144.8	1.82	2.09	2.92	2.76	1.80	1.35	0.83	0.32	0.29	0.32	0.71	1.28	1.37
1844C1	134.2	1.68	1.94	2.71	2.55	1.67	1.25	0.76	0.29	0.27	0.29	0.66	1.19	1.27
1844ZZ	10.6	0.119	0.150	0.221	0.204	0.130	0.099	0.059	0.017	0.018	0.018	0.051	0.099	0.098

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 292.7
SUM OF SUB-DRAINAGE AREAS = 289.6
TOTAL FLOW IN = 32.93
TOTAL FLOW OUT = 33.49

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1844A1	6	73	5.409	9	6.541				
	7	73	1.710	14	1.133				
	8	73	1.665	11	1.246				
	9	73	0.532	15	0.453				
	10	73	0.524	13	0.283				
	12	73	2.588	15	2.549				
	1	74	6.031	22	4.927				
	2	74	7.192	2	10.562	16	5.493		
	3	74	8.778	2	7.334	16	10.704		
	4	74	5.097	13	6.031				
	5	74	4.049	19	5.805				
1844A2	6	73	2.662	9	3.228				
	8	73	0.821	11	0.623				
	9	73	0.263	15	0.224				
	10	73	0.261	13	0.139				
	11	73	0.527	16	0.396				
	12	73	1.280	15	1.274				
	1	74	2.973	19	1.869				
	2	74	3.568	2	5.239	16	2.832		
	3	74	4.332	2	5.239	16	5.295		
	4	74	2.520	13	2.973				
	5	74	2.002	19	2.860				
1844C1	6	73	2.481	9	3.062				
	7	73	0.784	14	0.510				
	8	73	0.765	11	0.566				
	9	73	0.244	15	0.207				
	10	73	0.241	13	0.130				
	11	73	0.490	16	0.368				
	12	73	1.186	15	1.161				
	1	74	2.764	22	2.265				
	2	74	3.285	2	4.842	16	2.520		
	3	74	4.021	2	3.370	16	4.899		
	4	74	2.336	13	2.775				
	5	74	1.858	19	2.662				

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1844 LAKE TIPPECANOE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1844ZZ	6	73	0.195	9	0.238				
	7	73	0.062	14	0.042				
	8	73	0.059	11	0.045				
	9	73	0.020	15	0.017				
	10	73	0.020	13	0.011				
	11	73	0.040	16	0.031				
	12	73	0.093	15	0.093				
	1	74	0.218	19	0.139	22	0.178		
	2	74	0.261	2	0.396	16	0.198		
	3	74	0.311	2	0.266	16	0.396		
	4	74	0.184	13	0.218				
	5	74	0.147	19	0.210				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/03/30

184401
41 19 46.0 085 46 47.0 3
TIPPECANOE LAKE
18085 INDIANA

051792

11EPALES 2111202
0036 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/03	14 00	0000	13.2		120	495	8.20	200	0.070	0.800	1.200	0.006
	14 00	0004	13.2	9.2		500	8.20	201	0.060	0.600	1.000	0.004
	14 00	0020	12.9	9.4		500	8.20	201	0.060	0.700	0.100	0.002
	14 00	0032	11.9	9.1		500	8.20	200	0.060	0.700	1.100	0.003
73/08/04	14 05	0000	24.7			417	8.40	167	0.090	0.900	0.110	0.006
	14 05	0005	23.6	7.7		411	8.30	168	0.070	0.800	0.110	0.009
	14 05	0012	23.4	7.1		410	8.30	168	0.070	0.700	0.120	0.004
73/10/13	14 35	0000	19.8		110	380	8.30	171	0.090	1.200	0.050	0.022
	14 35	0005	19.5	6.0		380		171	0.110	0.900	0.060	0.013
	14 35	0015	19.0	5.4		380	8.00	174	0.140	0.800	0.070	0.012
	14 35	0024	18.4	3.6		384	7.80	171	0.160	0.900	0.100	0.013

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/03	14 00	0000	0.026	4.8
	14 00	0004	0.017	
	14 00	0020	0.019	
	14 00	0032	0.022	
73/08/04	14 05	0000	0.016	9.2
	14 05	0005	0.019	
	14 05	0012	0.016	
73/10/13	14 35	0000	0.026	2.9
	14 35	0005	0.016	
	14 35	0015	0.019	
	14 35	0024	0.023	

STORET RETRIEVAL DATE 76/03/30

184402
41 19 12.0 085 45 08.0 3
TIPPECANOE LAKE
18085 INDIANA

051792

11EPALES 2111202
0032 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/03	14	40 0000	13.4		96	500	8.20	203	0.060	0.800	1.000	0.003
	14	40 0004	13.3	9.7		500	8.30	204	0.050	0.600	1.100	0.002
	14	40 0015	13.3	9.4		500	8.30	200	0.050	0.600	1.100	0.002
	14	40 0028	13.3	9.2		500	8.30	203	0.050	0.800	1.000	0.002
73/08/04	14	25 0000	25.6	9.8		426	8.50	168	0.060	1.000	0.060	0.003
	14	25 0005	24.3	8.0		413	8.40	166	0.060	0.800	0.060	0.003
	14	25 0015	23.2	7.0		412	8.10	168	0.080	0.900	0.090	0.002
	14	25 0027	14.0			383	7.40	198	0.130	0.900	0.710	0.002K
73/10/13	15	00 0000	19.6		108	376	8.30	164	0.070	1.000	0.050	0.009
	15	00 0005	19.6	8.0		377	8.30	164	0.060	0.800	0.040	0.010
	15	00 0015	19.5	7.8		377	8.30	163	0.060	0.900	0.040	0.010
	15	00 0020	19.3	6.0		379	8.10	165	0.100	0.900	0.050	0.010
	15	00 0030	15.5	0.0		385	7.60	187	0.420	1.300	0.030	0.011

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/03	14	40 0000	0.025	5.5
	14	40 0004	0.028	
	14	40 0015	0.025	
	14	40 0028	0.027	
73/08/04	14	25 0000	0.016	9.6
	14	25 0005	0.016	
	14	25 0015	0.016	
	14	25 0027	0.013	
73/10/13	15	00 0000	0.019	4.3
	15	00 0005	0.018	
	15	00 0015	0.019	
	15	00 0020	0.019	
	15	00 0030	0.030	

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 75/03/30

184441
41 19 14.0 085 47 28.0 4
TIPPECANOE RIVER
18 7.5 LEESBURG
0/LAKE TIPPECANOE 051742
ARMSTRONG RD BRDG IN OSWEGO
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	13 55		0.690	1.600	0.066	0.005K	0.020
73/07/14	07 55		0.033	1.320	0.022	0.005K	0.030
73/08/11	11 00		0.023	1.680	0.046	0.007	0.027
73/09/15	14 05		0.012	0.960	0.031	0.006	0.025
73/10/13	10 50		0.033	0.980	0.105	0.028	0.040
73/12/15	08 50		0.192	0.900	0.160	0.005K	0.025
74/01/22	15 00		0.850	0.400	0.052	0.005	0.015
74/02/02	11 20		0.560	0.500	0.020	0.005	0.020
74/02/16	10 50		1.600	1.000	0.030	0.005	0.045
74/03/02	09 20		0.890	1.600	0.020	0.005K	
74/03/16	09 20		1.260	1.800	0.040	0.005	0.025
74/04/13	09 27		1.340	1.800	0.035	0.005	0.025
74/05/14	15 15		1.120	1.300	0.050	0.010	0.030

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

1817A1 and 1844A2
41 19 50.0 045 44 02.0 4
TIPPECANOE RIVER
18 7.5 N WEBSTER
O/JAMES LAKE 051792
BANK OFF PENINSULA IN BETWEEN THE LAKES
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	13 50		0.520	2.100	0.052	0.005	0.020
73/07/14	07 45		0.013	1.380	0.016	0.005K	0.020
73/08/11	11 30		0.010K	0.960	0.021	0.005K	0.015
73/09/04	13 50		0.022	1.050	0.040	0.007	0.025
73/10/13	10 40		0.011	0.900	0.028	0.005	0.030
73/11/10	12 30		0.270	1.250	0.168	0.007	0.040
73/11/16	12 54		0.034	0.950	0.231		0.026
73/12/15	09 30		0.156	0.900	0.168	0.008	0.025
74/02/02	11 00		1.260	1.100	0.060	0.010	0.060
74/02/16	10 40		1.900	1.700	0.050	0.015	0.095
74/03/02	09 05		0.460	1.900	0.230	0.015	0.055
74/03/16	09 00		1.430	3.300	0.060	0.005K	0.030
74/04/13	09 27		1.260	2.200	0.060	0.005	0.025
74/05/19	14 30		1.680	1.100	0.040	0.010	0.030

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

184481
41 19 30.0 085 46 25.0 4
UNNAMED STREAM
18 7.5 LEESBURG
T/LAKE TIPPECANOE 051792
STANTON RD BRDG .3 MI SE OF STONY RIDGE
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	14	10	0.025	2.600	0.098	0.140	0.200
74/03/02	09	25	0.064	1.300	0.030	0.050	0.210
74/03/16	09	15	0.060	1.500	0.025	0.020	0.075
74/04/13	09	41	0.004	1.800	0.050	0.035	0.065
74/05/19	14	00	0.028	3.100	0.190	0.055	0.065

STORET RETRIEVAL DATE 76/03/30

1H44C1
41 18 30.0 085 44 10.0 4
GRASSY CREEK
18 7.5 N WEBSTER
T/LAKE TIPPECANOE 051792
500 N RD BRDG NEAR PUBLIC FISHING SITE
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	12 45		1.000	2.310	0.060	0.005K	0.030
73/07/14	07 20		0.120	1.680	0.080	0.006	0.040
73/08/11	10 35		0.022	2.000	0.132	0.005K	0.040
73/09/15	13 15		0.010K	1.100	0.030	0.006	0.037
73/10/13	11 05		0.012	1.000	0.042	0.009	0.040
73/11/16	12 25		0.084	1.500	0.210	0.005K	0.032
73/12/15	10 00		0.216	0.600	0.056	0.012	0.025
74/01/22	14 45		0.460	0.500	0.020	0.005K	0.015
74/02/02	10 35		2.640	0.800	0.025	0.025	0.050
74/02/16	11 00		2.520	1.000	0.025	0.015	0.045
74/03/02	08 35		2.400	1.200	0.030	0.015	0.065
74/03/16	08 25		2.500	1.600	0.015	0.015	0.075
74/04/13	08 45		1.920	1.200	0.020	0.010	0.010
74/05/19	14 45		1.340	1.700	0.045	0.005	0.070

K VALUE KNOWN TO BE
LESS THAN INDICATED